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Solution by G. B. M. ZERR, A. M., Ph. D., Professor of Chemistry and Physics, The Temple College, Philadelphia, Pa.

Let v_1 = volume of gas at pressure P_1 .

v_2 = volume of gas at pressure P_2 .

v = volume of gas at pressure P .

Work done by isothermic expansion from v_2 to v_1 is

$$w = \int_{v_2}^{v_1} P dv.$$

But $P = P_2 v_2 / v$.

$$\therefore w = P_2 v_2 \int_{v_2}^{v_1} \frac{dv}{v} = P_2 v_2 \log(v_1 / v_2).$$

The work done against gravity by lifting C cubic feet of water through an average height $\frac{1}{2}l$ is $W = \frac{1}{2}Cl \times 62\frac{1}{2} = \frac{1}{4}lCl$.

Volume of water = $\frac{1}{4}\pi a D^2$, $v_1 = \frac{1}{4}\pi D^2(L - a)$.

$$v_2 = \frac{P_1 v_1}{P_2} = \frac{\pi D^2 P_1}{4 P_2} (L - a).$$

$$C = v_1 - v_2 = \frac{1}{4}\pi D^2 (L - a) \left(\frac{P_2 - P_1}{P_2} \right).$$

$$l = \frac{(L - a)(P_2 - P_1)}{P_2}, \quad \frac{v_1}{v_2} = \frac{P_2}{P_1}.$$

$$\therefore w = \frac{1}{4}\pi D^2 P_1 (L - a) \log\left(\frac{P_2}{P_1}\right).$$

$$W = \frac{1}{16}\pi D^2 (L - a)^2 \left(\frac{P_2 - P_1}{P_2} \right)^2.$$

Total work done = $w + W$.

Work done against pressure is the same as the work of expansion.

P_1 and P_2 are supposed to be given in pounds.

120. Proposed by W. J. GREENSTREET, M. A., Editor of The Mathematical Gazette, Stroud, Gloucestershire, England.

I project an elastic particle along a chord c of a smooth fixed circular rim of diameter d . The coefficient of elasticity between the particle and the rim is e , and the particle continually rebounds. Find the length of the chord described after the n th rebound.

Solution by G. B. M. ZERR, A. M., Ph. D., Professor of Chemistry and Physics, The Temple College, Philadelphia, Pa.

Let $\beta, \beta_1, \beta_2, \beta_3, \dots, \beta_n$ be the angles the particle makes with the diameter before the first and after the first, second, third, and n th rebound, respectively, x = length of chord after the n th rebound.

Then $\cot\beta=c/\sqrt{(d^2-c^2)}$.

$\cot\beta_1=ecot\beta=ec/\sqrt{(d^2-c^2)}$.

$\cot\beta_2=ecot\beta_1=e^2c/\sqrt{(d^2-c^2)}$.

.....

$\cot\beta_n=e^nc/\sqrt{(d^2-c^2)}=x/\sqrt{(d^2-x^2)}$.

$\therefore xcde^n/\sqrt{[d^2-c^2(1-e^{2n})]}$.

If $e=1$, $x=c$.

AVERAGE AND PROBABILITY.

102. Proposed by PROFESSOR CAVALLIN.

A random straight line is determined by two points taken at random within a sphere; find the average velocity acquired by a particle in descending the line. [No. 8742, *Educational Times*. Unsolved.]

Solution by G. B. M. ZERR, A. M., Ph. D., Professor of Chemistry and Physics, The Temple College, Philadelphia, Pa.

Let (x, y, z) , (u, v, w) be the coördinates of the two random points with center of sphere as origin. Let a =radius, $\sqrt{(a^2-x^2)}=y'$, $\sqrt{(a^2-u^2)}=v'$, $\sqrt{(a^2-x^2-y'^2)}=z'$, $\sqrt{(a^2-u^2-v'^2)}=w'$. The elevation of the one end of the line above the other $= (u-x)$.

Velocity $= \sqrt{[2g(u-x)]}$. The limits of x are $-a$ and a ; of u , x and a and doubled for the case when $u < x$; of y , $-y'$ and y' ; of z , $-z'$ and z' ; of v , $-v'$ and v' ; of w , $-w'$ and w' . Then since $(\frac{4}{3}\pi a^3)^2$ is the number of ways the two points can be taken, we get

$$\begin{aligned}\Delta &= \frac{2}{(\frac{4}{3}\pi a^3)^2} \int_{-a}^a \int_x^a \int_{-y'}^{y'} \int_{-z'}^{z'} \int_{-v'}^{v'} \int_{-w'}^{w'} \sqrt{[2g(u-x)]} dx du dy dz dv dw \\ &= \frac{9\sqrt{2g}}{8a^6} \int_{-a}^a \int_x^a \sqrt{(u-x)(a^2-x^2)(a^2-u^2)} dx du \\ &= \frac{3\sqrt{2g}}{35a^6} \int_{-a}^a (5a+2x)(a^2-x^2)(a-x)^{\frac{5}{2}} dx\end{aligned}$$

Let $x = a \cos \theta$.

$$\therefore \Delta = \frac{192\sqrt{ag}}{35} \int_0^\pi (7 - 4\sin^2 \frac{1}{2}\theta) \sin^{\frac{3}{2}} \theta \cos^{\frac{5}{2}} \theta d\theta = \frac{256\sqrt{ag}}{273}.$$

103. Proposed by LON C. WALKER, A. M., Assistant Professor of Mathematics, Leland Stanford Jr. University, Palo Alto, Cal.

A circle is drawn at random both in magnitude and position, but so as to lie wholly on the surface of a given semi-circle. Show that the chance that a